NATIONAL AERONAUTICS SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER

AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

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Director
Flight Projects Directorate

Presentation to Georgetown University
May 2015

NASA Overview

Image: Hubble Images a Swarm of Ancient Stars

- Founded in 1958, NASA is responsible for the nation's civilian space program and for aeronautics and aerospace research
- NASA shares data with various national and international organizations
- NASA employs roughly 18,000 civil servants and many more government contractors. The combined workforce is made of a variety of jobs and skill mixes
- NASA technology has contributed to many items used in everyday life, from smoke detectors to medical tests
- NASA's annual operating budget is approximately $16 billion

NASA Goals and Objectives

Mission: To drive advances in science, technology, and exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of the Earth.

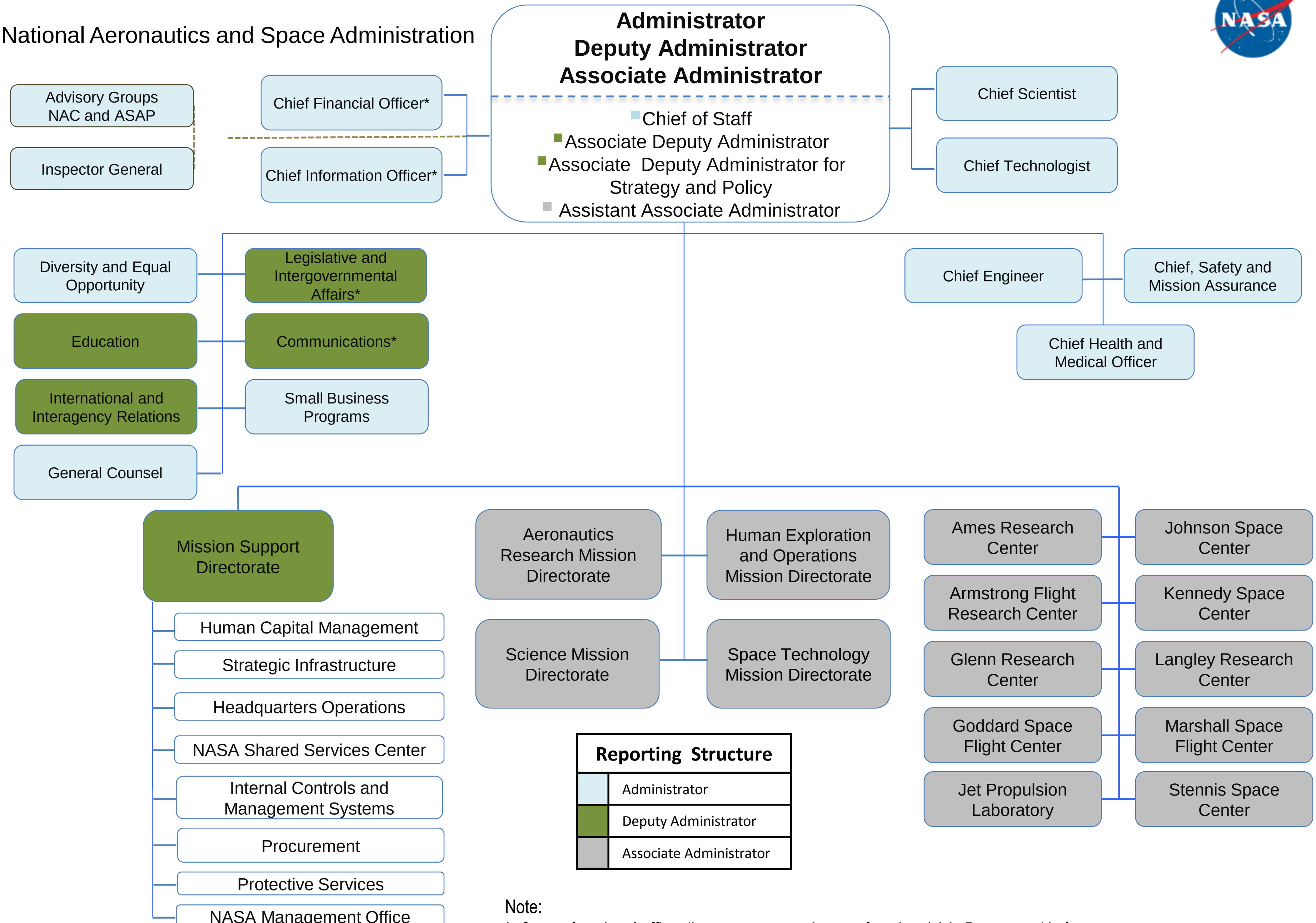
Vision: To reach for new heights and reveal the unknown so that what we do and learn will benefit all humankind.

Image: NASA Space Shuttle Program

Image: NASA Hubble Space Telescope (HST)

Image: NASA International Space Station (ISS)

National Aeronautics and Space Administration



Note:
* Center functional office directors report to Agency functional AA. Deputy and below report to Center leadership.

March 2014

www.nasa.gov

GODDARD VISION STATEMENT

To expand the knowledge of the Earth and its environment, the solar system, and the universe through observations from space.

To emphasize scientific investigation, development and operation of space systems, and advancement of essential technologies.

To undertake a broad program of scientific research, both theoretical and experimental, in the study of space phenomena and Earth sciences. The program ranges from basic research to flight experiment development and from mission operations to data analysis.

Image: 'Blue Marble' NASA/NOAA/GSFC/ Suomi NPP/VIIRS/Norman Kuring

Goddard Space Flight Center Overview

NASA's first space flight center was established in 1959

- Provides end-to-end Science and Technology Missions capabilities
- Integrates Science, Engineering, and Project Management
- Implemented nearly 300 missions – from the world's first weather satellite (1960) to Hubble Space Telescope servicing, James Webb Space Telescope, and beyond
- Develops and operates communication and navigation systems to meet NASA and National Program needs

Mission: We implement Earth, Space Science Communications and Technology Missions

- Conceive, develop, launch, and operate science and technology missions
- Address fundamental questions in Earth and Space Science
- Deliver data and information to the public in ways that they can use it

Our resources enable the accomplishment of our Mission

- Hire, develop, and nurture world class Scientists, Engineers, and Project Managers
- Provide in-house, hands on experience at the Center to foster employee development
- Evolve facilities to meet changing requirements
- Identify and aggressively pursue technology advancements that enable science breakthroughs

GODDARD SPACE FLIGHT CENTER LEADERSHIP

- **Office of the Director**
  Director – C. Scolese
  Deputy Director – G. Morrow
  Deputy Director for Technology and Research Investments – C. Johnson
  Deputy Director for Science, Operations and Program Performance – Vacant
  Associate Director – N. Abell
  Chief of Staff – T. Thompson
  - **NASA Inspector General**
  - **Equal Opportunity Programs**
  - **Communications**
  - **Chief Counsel**
  - **Education**
  - **Independent Verification & Validation Program**
  - **Human Capital Management**
  - **Finance**
  - **Management Operations**
  - **Safety & Mission Assurance**
  - **Flight Projects**
    Director – D. Mitchell
    Deputy – Vacant
    Deputy Planning & Business Management – S. Shinn
    - Advanced Concepts & Formulation
    - Business Management
    - Resource Analysis
    - Earth Science Technology
    - Satellite Servicing Capabilities
    - Instrument Projects
    - Geostationary Operational Environmental Satellite
    - Earth Science Projects
    - Planetary Projects
    - Astrophysics Projects
    - James Webb Space Telescope
    - Exploration & Space Communications Projects
    - Explorers & Heliophysics Projects
    - Joint Polar Satellite System
  - **Applied Engineering & Technology**
  - **Sciences & Exploration**
  - **Information Technology & Communications**
  - **Suborbital & Special Orbital Projects**

Flight Projects Directorate Mission

The Flight Projects Directorate (FPD) "enables" Earth and Space Science, and Exploration. We utilize an integrated approach - science, engineering, safety and mission assurance and management - to enable us to take on and accomplish the most challenging of missions.

The overarching principle of the FPD is to define the problem that needs to be solved and demonstrate that the course of action being pursued contributes directly to the solution.

Mission Phase:
Pre-A=Purple
A=Red
B=Blue
C/D=Green
E=Brown
(Operations)

FLIGHT PROJECTS DIRECTORATE - Code 400

David F. Mitchell, Director of
Vacant, Deputy Director of
Stephen A. Shinn, Deputy Director for Planning & Business Management
Mark Brumfield, Associate Director
Dan Blackwood, Assistant Director
Cecilia Czarnecki, Assistant Director
Donna Swann, Assistant Director

ADVANCED CONCEPTS & FORMULATION
Code 401
John Vansant, Associate Director for Formulation
Antonios Seas, Dpty Prg Mgr
-RSDO (401.1)

FPD BUSINESS MANAGEMENT OFFICE
Code 403
Stephanie Gray (Acting)
Resource Management Officer

RESOURCE ANALYSIS OFFICE
Code 405
Cynthia Fryer, Chief
Harry Born, Dpty Chief

EARTH SCIENCE TECHNOLOGY OFFICE
Code 407
George Komar, Associate Director
Robert Bauer, Dpty Prg Mgr

SATELLITE SERVICING CAPABILITIES OFFICE
Code 408
Frank Cepollina, Associate Director
Benjamin Reed, Dpty Prj Mgr
Brett Weeks, Dpty Prj Mgr Res
-RESTORE
-FARMS
-RAVEN
-RRM

GOES-R PROGRAM
Code 410
Greg Mandt (NOAA), Sys Prg Dir
Sandra Cauffman, Dpty Sys Prg Dir
Michael Stringer (NOAA), Asst Sys Prg Mgr
Stephen Schaeffer (NOAA), Prg Ctl Lead
-GOES-R Ground (416)
-GOES-R Flight (417)

JAMES WEBB SPACE TELESCOPE PROJECT
Code 443
William Ochs, Associate Director
John Durning, Dpty Prj Mgr
Paul Geithner, Dpty Prj Mgr Tech
Richard Ryan, Dpty Prj Mgr Res

EARTH SCIENCE PROJECTS DIVISION
Code 420
Thomas McCarthy, Associate Director
ESM Prg Mgr, & Reimbursable Prj Prg Mgr
Eric Ianson, Dpty Assoc Dir
Kathy Shifflett, Prg Bus Mgr
-POES (421)
-ESDIS (423)
-SIDAR (424)
-ICESat-2 (425)
-DSCOVR (426)
-PACE (427)
-ESMO* (428)
-LANDSAT 9 (429)

PLANETARY SCIENCE PROJECTS DIVISION
Code 430
David Mitchell (Acting)
Associate Director
-OSIRIS REx (433)

ASTROPHYSICS PROJECTS DIVISION
Code 440
Mansoor Ahmed, Associate Director & PCOS/COR Prg Mgr
Thomas Griffin, Dpty Prg Mgr for PCOS
Tracy Parlate (Acting), Prg Bus Mgr
-HST Operations (441)
-SSMO** (444)
-AFTA (448)

EXPLORATION & SPACE COMMUNICATION DIVISION
Code 450
Robert Menrad, Assoc Dir
George Jackson, Dpty Prg Mgr/Flt Impl
Cathy Barclay, Dpty Prg Mgr/Tech
Tracy Felton, Prg Bus Mgr
-NIMO (450.1)
-SAR (450.3)
-LCRD (451)
-SN (452)
-NEN (453)
-TDRS (454)
-ES (455)
-SGSS (458)

EXPLORERS & HELIOPHYSICS PROJECTS DIVISION
Code 460
Nicholas Chrissotimos, Assoc Dir, LWS, STP, & Exp Prg Mgr
Greg Frazier, Exp Dpty Prg Mgr
Michael Delmont, LWS/STP Dpty Prg Mgr
Mark Goans, APL Prj Dpty Prg Mgr
Joe Burt, Dpty Prg Mgr/Tech
Christine Hinkle, Exp Prg Bus Mgr
Pietro Campanella, Helio Prg Bus Mgr
-GOLD (460)
-ICON (460)
-SET (460)
-SPP (460)
-TESS (460)
-MMS (461)
-SOC (464)

JOINT POLAR SATELLITE SYSTEM PROGRAM
Code 470
Preston Burch, Associate Director
Lillian Reichenthal, Dpty Prg Mgr
Jacqueline Townsend, Dpty Prg Mgr
Hsiao Smith, Dpty Prg Mgr
Linda Greenslade, Prg Bus Mgr
-JPSS Flight (472)
-JPSS Ground (474)

INSTRUMENT PROJECTS DIVISION
Code 490
Kenneth Schwer, Associate Director
Robert Lilly, Dpty Div Mgr
Laura Milam-Hannin, Dpty Div Mgr
Robert White, Div Bus Mgr
-MOMA-MS (490.1)
-ASTRO-H SXS (490.2)
-NIRSpec (490.3)
-SMAP (490.5)
-ATLAS (491)
-FPI (492)
-LCRD Payload (493)
-OVIRS (494)
-NICER (495)
-GEDI-LIDAR (496)
-ORCA (TBD)

*AQUA, AURA, EO-1, GPM, LANDSAT 7&8, SORCE, TERRA, TRMM
**ACE, AIM, ARTEMIS, FERMI, GEOTAIL, IBEX, IRIS, LRO, MAVEN, RHESSI, SDO, SOHO, STEREO, SWIFT, THEMIS, TIMED, VAN ALLEN PROBES, WIND

As of 5/1/2015

ROLE OF THE FLIGHT PROJECTS DIRECTORATE

- The Flight Projects Directorate via the assigned project managers provides the following services and products to enable the vision of the customer:
  - Leadership and advocacy
  - Forming and directing the team of technical experts required for project formulation and implementation
  - Managing the development of mission critical technologies
  - Initiating in-house studies or contractual solicitations
  - Controlling available resources
  - Reporting status and progress to program and GSFC management
  - Executing project activities in accordance with the GSFC Quality Management System, ISO 9001 standards and NPR 7120.5E

AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

FLIGHT PROJECTS' SERVICES

Flight Projects Directorate is responsible for overall management and implementation of flight, ground, and instrument projects at Goddard Space Flight Center

IDEA

DESIGN

FORMULATION/ INTEGRATION

TEST

LAUNCH

OPERATIONS

DATA ANALYSIS

FUNCTION	DESCRIPTION OF SERVICES
Leadership	Deliver vision, context and enable performance to achieve customer needs
Technical Expertise	Direct and train team of technical experts through formulation and implementation
Mission Development	Manage mission formulation and implementation for both in- and out-of-house
Project Control	Provide planning, resource management, and the latest methods, tools, and practices
Monitoring & Guidance	Assess performance; guide consistency, effectiveness, timeliness, and accountability
Advocacy	Liaise with external stakeholders on behalf of flight projects
Compliance & Control	Execute project activities in accordance with Center, Agency, and Federal standards
Mission Support	Offer mission support services for Space and Earth Science flight projects/missions
Knowledge Management	Recognize, collect, represent, and enable the delivery of and adoption of insights and experiences that will improve performance

FLIGHT PROJECTS' GODDARD SPACE FLIGHT CENTER RESOURCES

GSFC Engineering Facilities

- Vibration Test
- Acoustic Test
- Modal Survey Test
- Thermal Vacuum Test
- EMI/EMC Test
- High Capacity Centrifuge
- Static Test
- Mass Prop Measurement
- Clean Room Integration Areas

GSFC Science and Exploration Facilities

- Balloon Payload Integration High Bay
- Center for Climate Simulation Facility
- Visual and Technical Arts Laboratory
- Radiometric Calibration and Development Facility
- Snow and Ice Research Facility

As well as various laboratories specialized for assorted sciences including Earth, Astrophysics, Heliophysics, and the Solar System

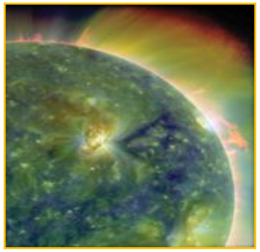
AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

MAJOR CHAMPIONS

Science Mission Directorate (SMD)

Earth

Heliophysics



Planetary

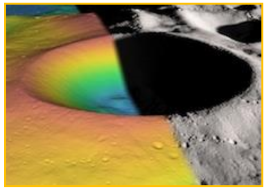
Astrophysics

Human Exploration and Operations Mission Directorate (HEOMD)

Exploration Studies

Space Communications

International Space Station

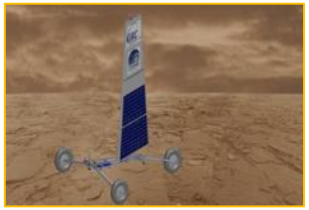


Lunar Science

Science Technology Mission Directorate (STMD)

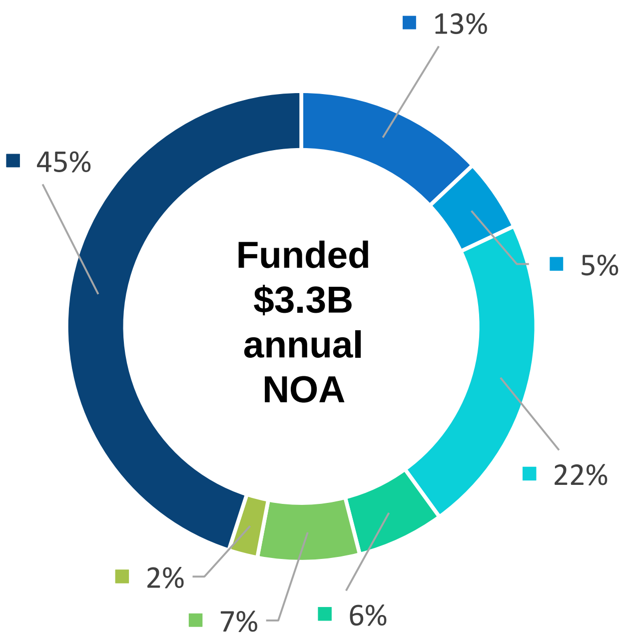
Building

Testing



Flying

OUR FY 2015 ANNUAL PORTFOLIO



FPD WORKFORCE

- 408 Civil Service Employees
- 859 contractors
- 1,267 Total Employees

Earth Science Reimbursable – 45%
FY14 NOA: $1,510M
Projects in Development: 3
Total in Operations: 1

Planetary – 5%
FY14 NOA: $169.7M
Projects in Development: 1
Total in Operations: 1

Heliophysics – 6%
FY14 NOA: $184.7M
Projects in Development: 8
Total in Operations: 18

Cross-cutting Technologies – 2%
FY14 NOA: $61.9**
Projects in Development: 3
Total in Operations: 1

Earth Science – 13%
FY14 NOA $414.6M
Projects in Development: 5
Total in Operations: 12

Astrophysics – 22%
FY14 NOA: $716.7M
Projects in Development: 4
Total in Operations: 4

Communications & Navigation – 7%
FY14 NOA: $227.4M
Projects in Development: 3
Total in Operations: 5*
**Includes NIMO and SAR*

The Flight Projects Directorate manages a myriad of in-house and out-of-house flight projects that concentrate on earth and space science, and exploration.

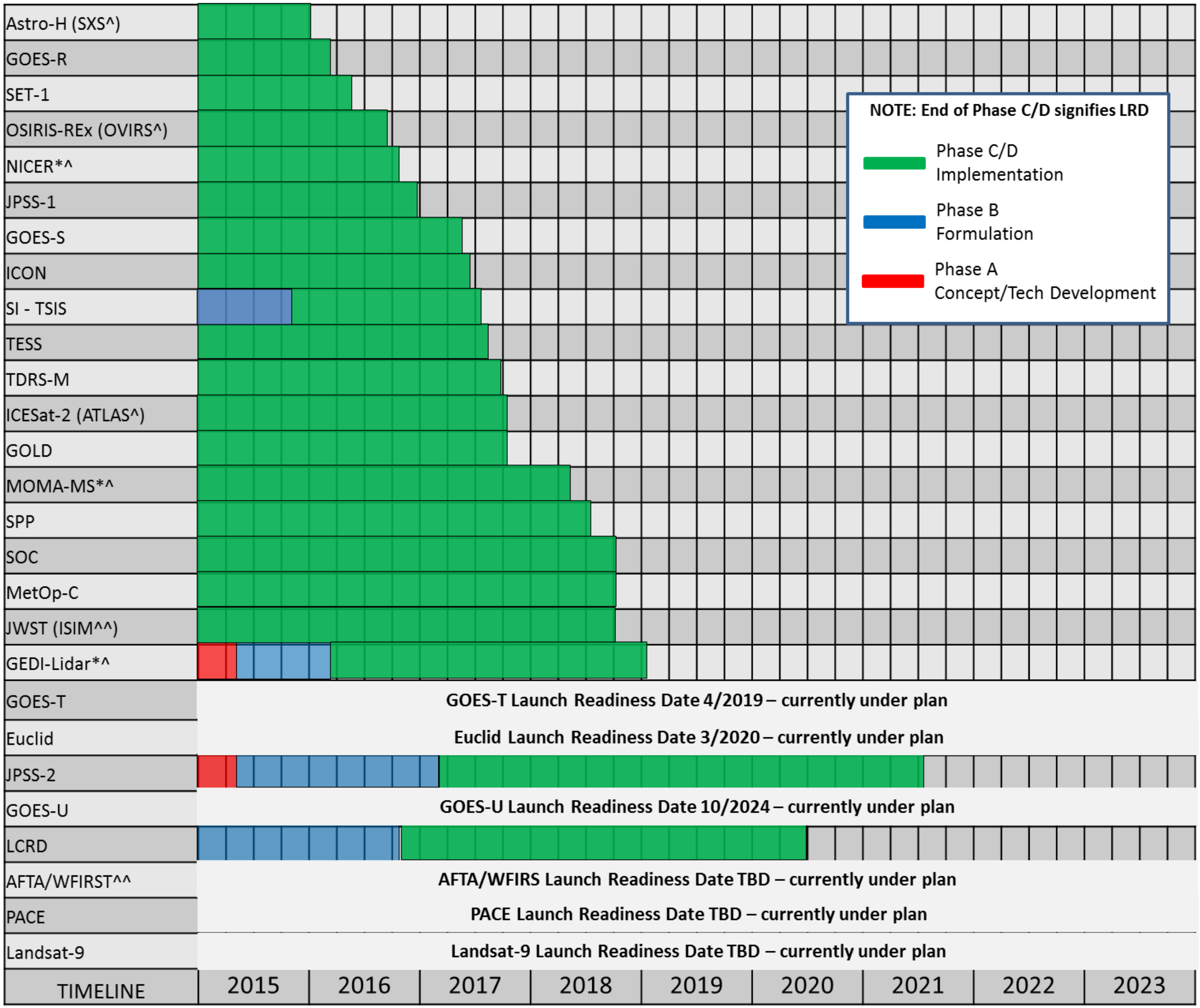
An integrated approach to science, engineering, safety and mission assurance, and management enables us to take on and accomplish the most challenging of missions.

These make for exciting times for Goddard and all of our partners.

Mission Portfolio

As of 3.3.2014

GSFC FPD Mission Horizon



(Project Name^) Denotes in-house instrument build

(Project Name^^) Denotes in-house module build and I&T; instruments were developed out-of-house

*Denotes instrument contribution ONLY

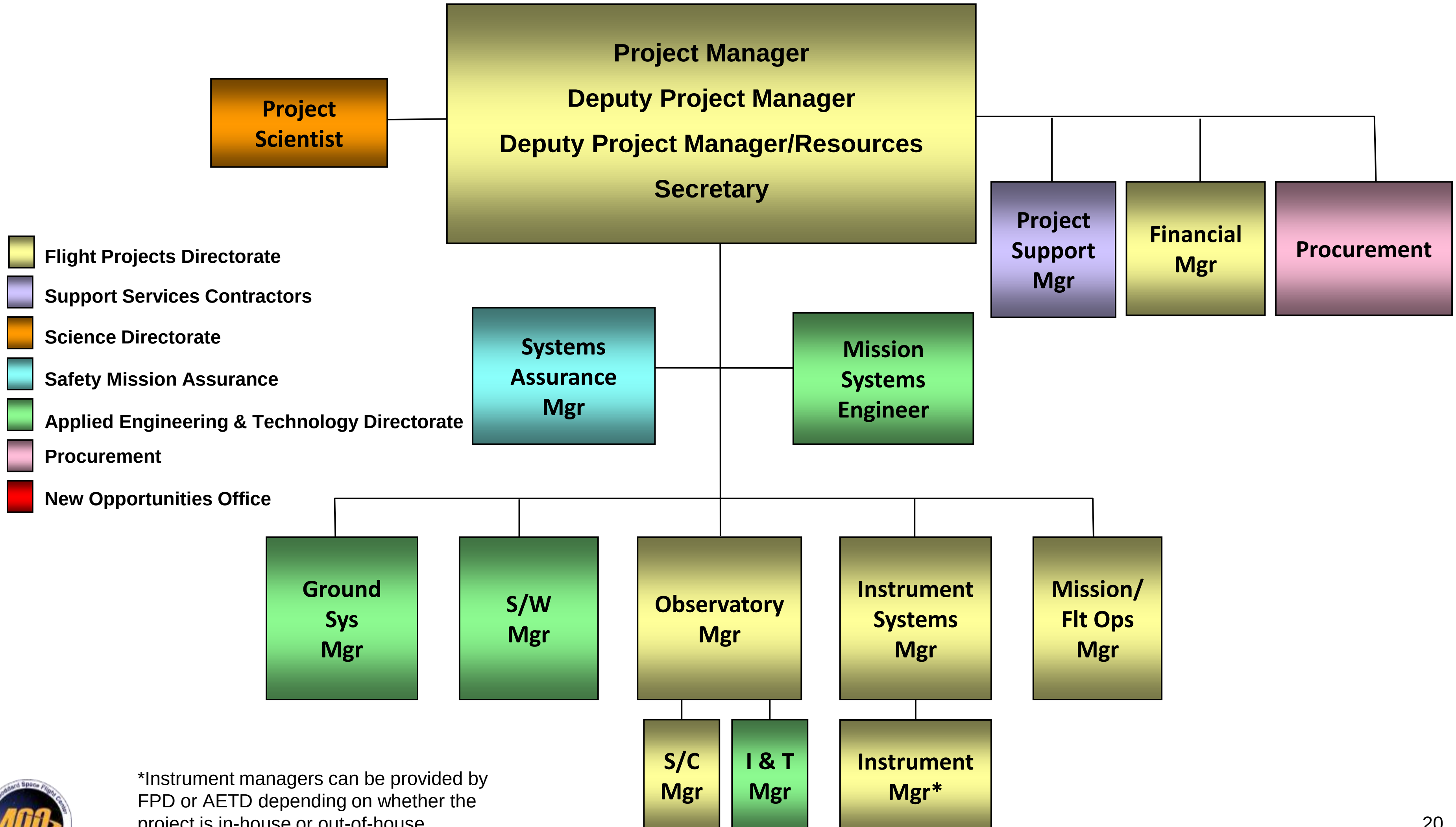
Project Management: Principles to Success

1. *Establish a clear and compelling vision*
   – Create a clearly defined vision of the future that serves to inspire and motivate the project team which in turn provides an important first step in paving the road toward project success
2. *Secure sustained support "from the top"*
   – Develop effective working relationships with key stakeholders at all levels
3. *Exercise strong leadership and management*
   – Identify and develop other leaders and technical staff within the organization, define clear lines of authority and demand accountability
4. *Facilitate wide open communication*
   – Listen and share the good, the bad and the ugly
5. *Develop a strong organization*
   – Design and align culture, rewards, and structure
6. *Manage risk/seek opportunities*
   – Employ a continuous and evolving risk-management process
   – Look forward then exploit opportunities to reduce cost or schedule requirements through agile principles
7. *Establish, maintain, and implement an executable baseline*
   – Develop clear, stable objectives/requirements from the outset; establish clean interfaces; track changes, implement corrective actions when necessary; and maintain effective configuration control

ORGANIZATION

- Don't confuse the ubiquitous organization chart for the organization!
- **The goal in a project organization is to develop a collection of people engaged in work and communication patterns to effectively and efficiently produce the required results**
- Each project presents a unique set of organizational requirements and priorities
- The organization should promote the teams dominant interfaces and communication channels
- The purpose of the organization is to ensure that project requirements are met

TYPICAL PROJECT ORGANIZATION PHASES B/C/D

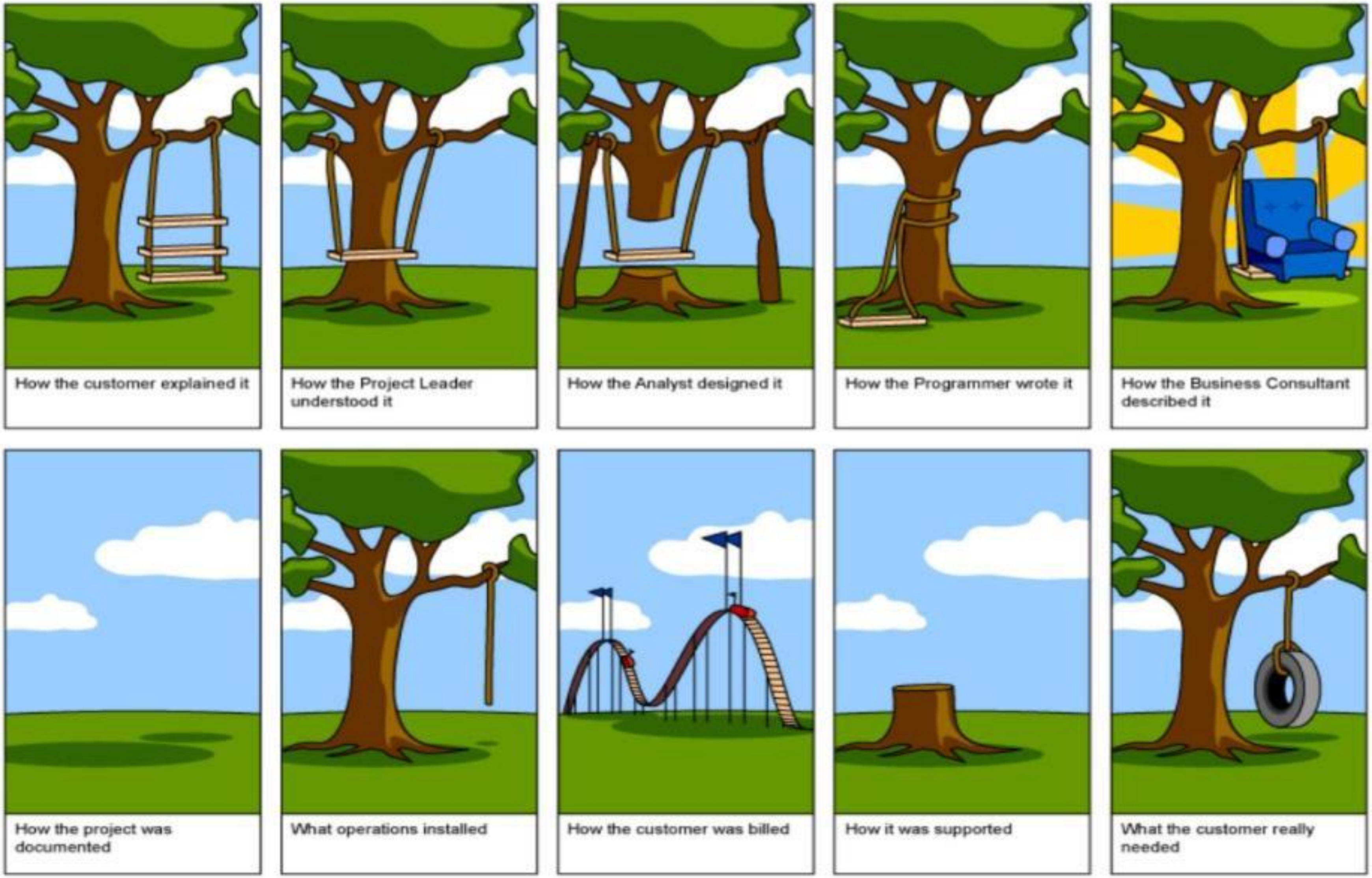


*Instrument managers can be provided by FPD or AETD depending on whether the project is in-house or out-of-house

Team Formation

- Forming the team starts with selecting the right people and defining their roles
- Team formation is a situational process, ongoing throughout the project cycle
- Project team goes beyond the traditional staffing function. It includes the definition and management of
  - Interfaces with supporting organizations
  - Contractors
  - Upper management
  - Customer
- Roles and responsibilities must be clear
- Team members need to understand where they fit in the project

REQUIREMENTS CYCLE



WHAT IS A GOOD REQUIREMENT?

- A good requirement clearly states a verifiable and attainable need
  - Just because a sentence contains the word “shall” doesn't mean it is an appropriate requirement
- Every requirement must have three characteristics
  1. Needed — What is the worst thing that could happen if I delete this requirement?
  2. Verifiable — We must be able to verify that the product does what the requirement says
  3. Attainable — If a requirement is technically impossible or can't be achieved within the current budget and schedule, we shouldn't include it

Everybody Wants to Understand Risk

We all manage risks, but we have a hard time doing risk management!

WHY DO RISK MANAGEMENT

Risk management??

In simplest terms, risk management is an organized process to identify risks, their likelihood and severity, and deal with them up front

But done in a more formalized manner

AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

LIFE CYCLE OF A GODDARD MISSION

Construction
Project teams develop, manufacture, and integrate technology to build the mission to the requirements

Test
Project teams tests all missions to ensure each project will survive launch and the conditions of space to operate as intended

Launch
Engineers provide telemetry, tracking, and other support for launches from across the world

Design
Scientists and engineers work jointly to develop missions that will capture the observations needed

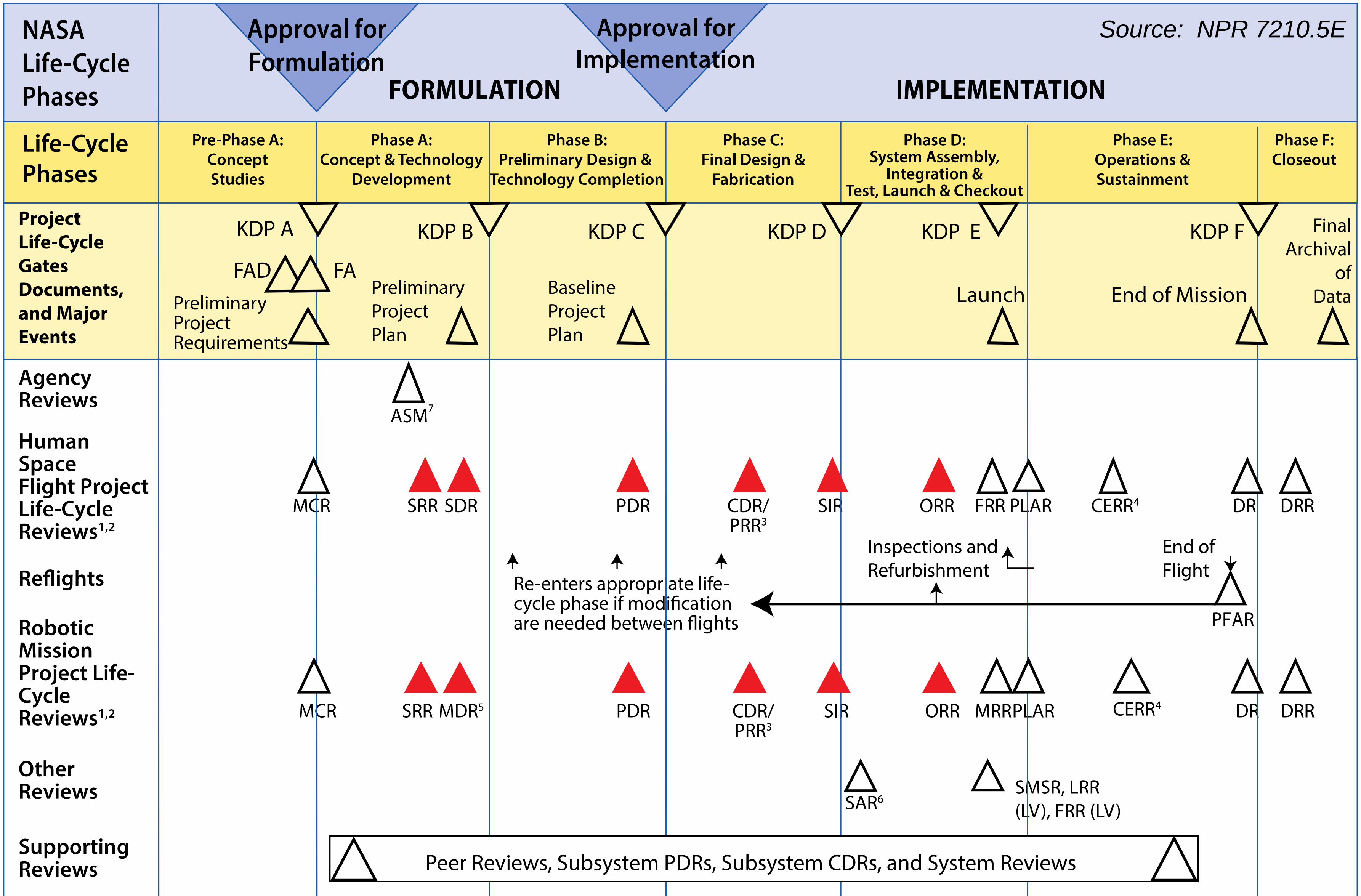
Operations
Spacecraft mission operations ensure data is returned timely and missions remain operational

Idea
Scientists take foundational ideas to map them into methods for exploring

Data Analysis
Data informs scientists to influence missions of the future; data is also used to drive development of new technology

Goddard is one of the few worldwide organization to manage a mission from concept to operations utilizing expertise and resources from partners, industry, and in-house to execute to the requirements

AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED



Pre-Phase A — Concept Studies

Activity - Evaluation of a broad spectrum of ideas and alternatives for new missions including mission concepts, requirements, and technology needs in preparation for Mission Concept Review (MCR)

MCR Description - To evaluate the feasibility of the proposed mission concept(s) and its fulfillment of the program's needs and objectives. To determine whether the maturity of the concept and associated planning are sufficient to begin Phase A

Key Decision Point (KDP)-A Gate Products

- Preliminary Mission Concept Report
- Draft Integrated Baseline

Control Gate to Next Phase

- MCR
- KDP-A decision by the Decision Authority
- Issuance of the Formulation Authorization Document (FAD) by the Mission Directorate Associate Administrator (MDAA)

NOTE: *Excellent sources for the context, background, purpose, entrance criteria, timing, objectives, and success criteria of the reviews referenced in this presentation are:*

- *GSFC-STD-1001 (Guidance for Successful Accomplishment of Integrated Independent Reviews) - this document will be updated to reflect the 7120 review definitions*
- *NPR 7123.1A (NASA Systems Engineering Processes and Requirements)*
- *Interim NASA Space Flight Program And Project Management Handbook (Office of the Chief Engineer)*

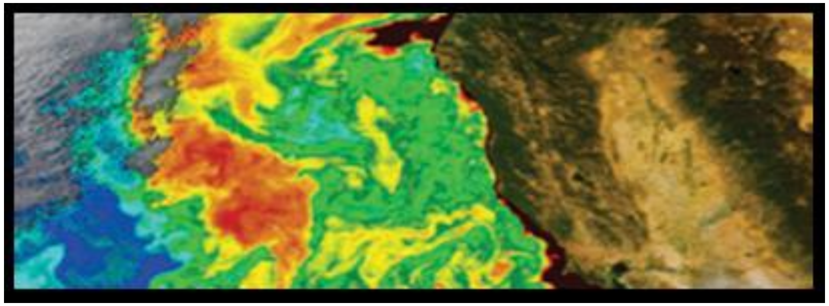
PACE — PRE-AEROSOL, CLOUDS, AND OCEAN ECOSYSTEM

Current Phase:

Pre-Phase A

Launch Readiness Date:

TBD



Mission Objectives

- Make essential global ocean color measurements
- Understand carbon cycle
- Provide extended data records on clouds and aerosols

Instruments

- Ocean Ecosystem Spectrometer/Radiometer
- Aerosol/Cloud Polarimeter (CNES partnership)

Lead Organization: NASA GSFC

Phase A — Concept & Technology Development

Activity - Formation of project team, development of baseline mission concept, define/begin development of needed technologies - Preparation for the Mission Design Review (MDR)

MDR Description - To evaluate the credibility and responsiveness of the proposed mission/system architecture to the program requirements and constraints, including available resources. To determine whether the maturity of the project's mission/system definition and associated plans are sufficient to begin Phase B

Key Decision Point (KDP)-B Gate Products

- Baseline Mission Concept Report
- Preliminary System Level Requirements
- Preliminary Mission Operations Concept
- Preliminary Integrated Baseline
- Preliminary Project Plan
- Preliminary Cost Analysis Data Requirement (CADRe) for Category 1 and 2 projects

Control Gate to Next Phase

- MDR - May be combined with System Requirements Review (SRR)
- Standing Review Board (SRB) presents findings from the MDR to the project, Goddard Center Management Council (CMC)*, and Governing Program Management Council (PMC)
- KDP-B decision by the Decision Authority

* *The report-out of the SRB to the Goddard CMC takes place at the Initial Confirmation Readiness Review. For Science Mission Directorate (SMD) projects, this is followed by the Initial Confirmation Review at HQ. Category 1 missions will have to go on to the Agency PMC for approval.*

GEDI — GLOBAL ECOSYSTEM DYNAMICS INVESTIGATION LIDAR

Current Phase:

Phase A

Launch Readiness Date:

March 2019

Mission Objectives

- Quantify the distribution of above-ground carbon at fine spatial resolution
- Quantify changes in carbon resulting from disturbance and subsequent recovery
- Quantify the spatial and temporal distribution of forest structure and its relationship to habitat quality and biodiversity
- Quantify the sequestration potential of forests through time under changing land use and climate

Instrument

- GEDI will be mounted on the International Space Station

Lead Organizations:

- Principal Investigator – University of Maryland, College Park, MD
- Instrument – NASA GSFC

Phase B — Preliminary Design and Technology Completion

Activity - Completion of preliminary design and technology development - Preparation for the Preliminary Design Review (PDR)

PDR Description - To evaluate the completeness/consistency of the planning, technical, cost, and schedule baselines developed during Formulation. To assess compliance of the preliminary design with applicable requirements and to determine if the project is sufficiently mature to begin Phase C

Key Decision Points (KDP)-C Gate Products

- Baseline System Level Requirements
- Baseline Preliminary Design Report
- Baseline Mission Operations Concept
- Baseline Integrated Baseline
- Baseline Technology Readiness Assessment
- National Environmental Protection Act (NEPA) documentation
- Baseline Preliminary CADRe for Category 1 and 2 projects
- Baseline International and Interagency Agreements
- Baseline Project Plan
- Preliminary Missile System Pre-launch Safety Package
- Initial Orbital Debris Assessment

Control Gate to Next Phase

- PDR
- SRB presents findings from the PDR to the project, Goddard CMC*, and Governing PMC
- KDP-C decision by the Decision Authority

* *The report-out of the SRB to the Goddard CMC takes place at the Confirmation Readiness Review. For SMD missions, this is followed by the Confirmation Review at HQ. Category 1 projects will have to go on to the Agency PMC for approval.*

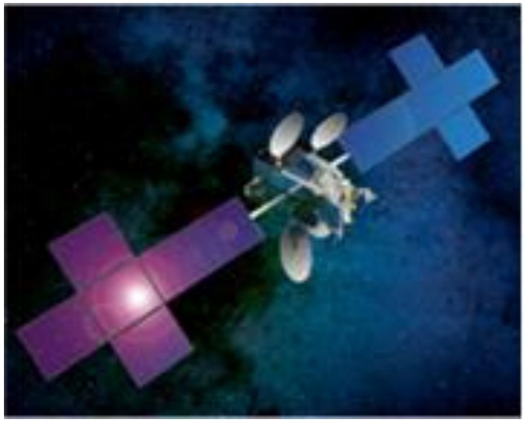
LCRD — Laser Communication Relay Demonstration

Current Phase:

Phase B

Launch Readiness Date:

TBD



Mission Objectives

- Demonstrate bidirectional optical communications between geosynchronous Earth orbit (GEO) and Earth
- Measure and characterize the system performance over a variety of conditions
- Develop operational procedures and assess applicability for future missions
- Transfer laser communication technology to industry for future missions
- Provide an on orbit capability for test and demonstration of standards for optical relay communications

Instrument

- Payload Optical Flight Terminal Relay

Lead Organization: NASA GSFC

Phase C — Final design and Fabrication

Activity - Completion of final design, begin fabrication of test and flight article components, assemblies, and subsystems - Preparation for the System Integration Review (SIR)

SIR Description - To evaluate the readiness of the project and associated supporting infrastructure to begin system AI&T, evaluate whether the remaining project development can be completed within available resources, and determine if the project is sufficiently mature to begin Phase D

Key Decision Point (KDP)-D Gate Products

- Baseline Detailed Design Report
- Preliminary Operations Handbook
- Updated Preliminary CADRe for Category 1 and 2 projects
- Baseline Missile System Pre-launch Safety Package
- Preliminary Orbital Debris Assessment
- Preliminary Decommissioning/Disposal Plan

Control Gate to Next Phase

- SIR
- SRB presents findings from SIR to the project, Goddard CMC, and Governing PMC
- KDP-D* decision by the Decision Authority

* *KDP-D is a soft gate (i.e., upon completion of the Phase C products, the project may immediately initiate Phase D work, barring direction to the contrary from the Program Manager).*

ICESAT 2 — ICE, CLOUD, AND LAND ELEVATION SATELLITE

Current Phase:

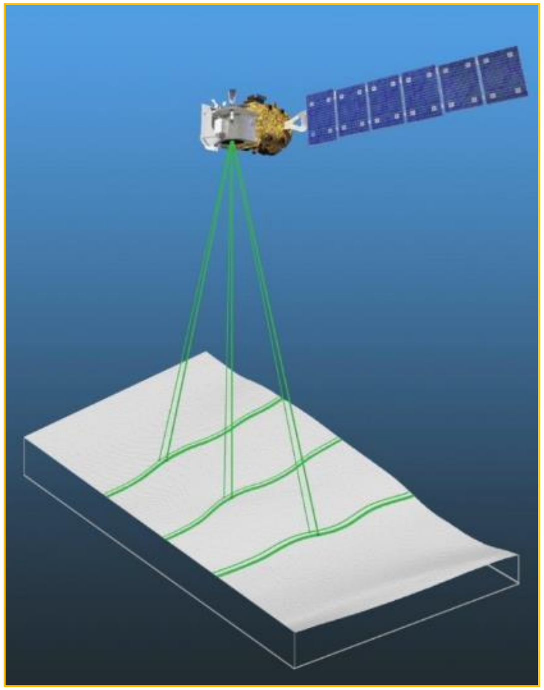
Phase C

Launch Readiness Date:

October 2017

Mission Objectives

- Quantifying polar ice-sheet contributions to current and recent sea-level change and the linkages to climate conditions
- Quantifying regional signatures of ice-sheet changes to assess mechanisms driving those changes and improve predictive ice sheet models
- Estimating sea-ice thickness to examine ice/ocean/atmosphere exchanges of energy, mass and moisture
- Measuring vegetation canopy height as a basis for estimating large-scale biomass and biomass change



Instruments

- ATLAS - Advanced Topographical Laser Altimeter System

Lead Organization: NASA GSFC

Phase D — System Assembly, Integration and Test, Launch

Activity - Completion of system assembly, integration and test - Preparation for the Flight Readiness Review (FRR)

FRR Description – To evaluate the readiness of the project and all project and supporting systems for a safe and successful launch and flight/mission

Key Decision Point (KDP)-E Gate Products

- Baseline Operations Handbook
- Baseline as-built Hardware & Software Documentation
- Baseline Validation & Verification Report
- Updated Missile System Pre-launch Safety Package
- Baseline Orbital Debris Assessment

Control Gate to Next Phase

- FRR
- SRB presents findings from FRR (or equivalent) to the project, Goddard CMC*, and Governing PMC
- KDP-E decision by the Decision Authority

* *The report-out of the SRB to the Goddard CMC takes place at the Mission Readiness Review. For SMD missions, this is followed by the Mission Readiness Briefing at Headquarters. Category 1 projects may have to go on to the Agency PMC for final approval.*

OSIRIS-REx — Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer

Current Phase:

Phase D

Launch Readiness Date:

September 2016

Mission Objectives

- Return and analyze a sample of Bennu
- Map the global properties of Bennu
- Characterize the properties of the regolith at the sampling site in situ
- Measure the Yarkovsky effect on Bennu
- Compare properties of Bennu with ground-based telescopic data of the entire asteroid population.

Instruments

- OCAMS: OSIRIS-REx CAMera Suite
- OTES: OSIRIS-REx Thermal Emission Spectrometer
- OVIRS: OSIRIS-REx Visible and InfraRed Spectrometer
- OLA: OSIRIS-REx Laser Altimeter
- REXIS: REgolith X-ray Imaging Spectrometer

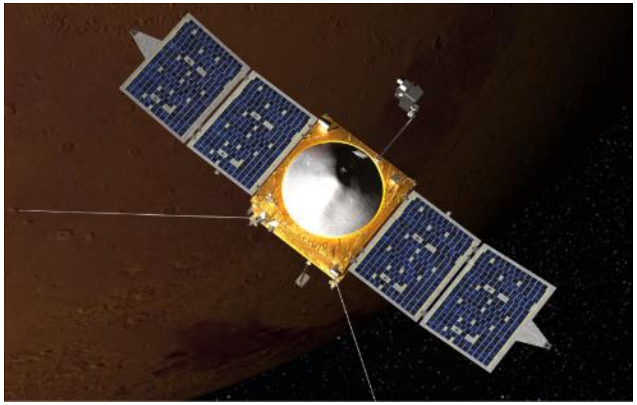
Lead Organizations:

- Principal Investigator – The University of Arizona
- Project Management and OVIRS Instrument – NASA GSFC

Phase E & F — Operations and Closeout

- Transition from Phase D to Phase E occurs when on-orbit checkout has been completed — typically 30 to 90 days after launch
- At GSFC, a "Commissioning Review" takes place at that time and the responsibility for mission operations transitions from the Project to either the Earth or Space Science Mission Operations Office. This is the equivalent of the Post-Launch Assessment Review (PLAR) described in NPR 7120.5E
- At the end of the nominal operational lifetime of the mission, HQ may decide (on the basis of science and programmatic data provided by the Center) to go into "Extended Operations". A formal decision is made – KDP-F - to continue operations or to initiate decommissioning
- At the end of the useful lifetime of the mission, a Decommissioning Review is held to confirm readiness to proceed with the safe decommissioning and disposal of mission assets in accordance with NASA policy on limiting orbital debris
- Note that the participation of the Standing Review Board is significantly diminished in these post-launch reviews

MAVEN — MARS ATMOSPHERE AND VOLATILE EVOLUTION MISSION



Current Phase:

Phase E

Launched:

November 2013

Mars Orbit Insertion:

September 2014

Mission Objectives

- Determine the role that loss of volatiles from the Mars atmosphere to space has played through time
- Determine the current state of the upper atmosphere, ionosphere, and the interactions with the solar wind
- Determine the current rates of escape of neutrals and ions to space and the processes controlling them
- Determine the ratios of stable isotopes that will tell Mars' history of loss through time

Instruments

- PFP - Particles and Fields Package
  - SWEA - Solar Wind Electron Analyzer
  - SWIA - Solar Wind Ion Analyzer
  - STATIC – Supra-Thermal and Thermal Ion Composition
  - SEP – Solar Energetic Particle
  - LPW - Langmuir Probe and Waves
  - MAG - Magnetometer
- IUVS – Imaging UltraViolet Spectrometer
- NGIMS - Neutral Gas and Ion Mass Spectrometer

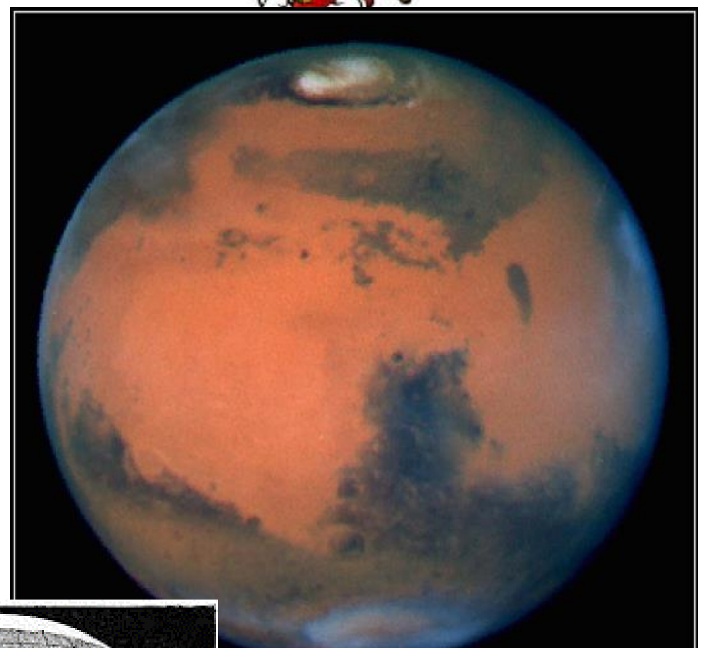
Lead Organizations:

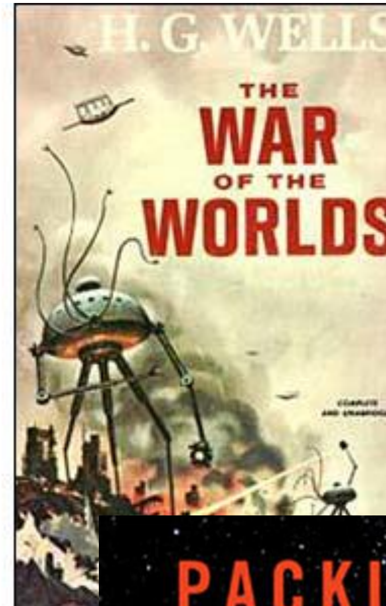
- Principal Investigator – University of Colorado, Laboratory of Atmospheric and Space Physics
- Project Management and NGIMS and MAG Instruments – NASA GSFC

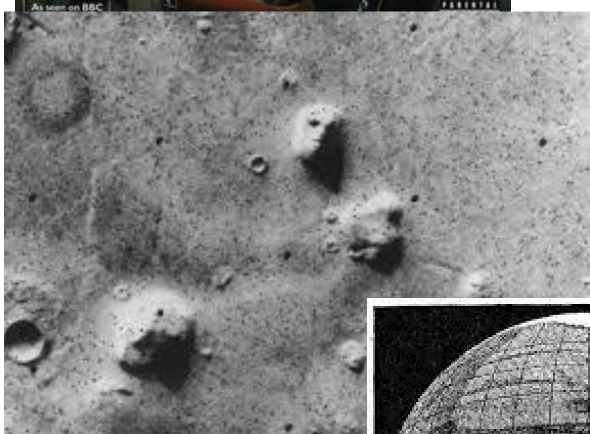
MAVEN HISTORICAL PERSPECTIVE

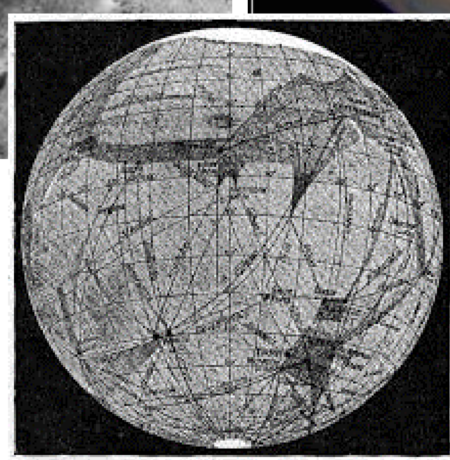
- The concept which became MAVEN was hatched in 2003 by one scientist from the University of Colorado/Boulder (eventual Principal Investigator) and two scientists from the University of California/Berkeley
- The MAVEN PI asked Goddard to join the team in 2005. The MAVEN proposal was submitted in response to the NASA HQ Scout II Announcement of Opportunity (AO) in 2006
- MAVEN was one of 20 proposals submitted at that time. Two were selected for a more-detailed feasibility or Phase A study
- Following the competitive Phase A study, MAVEN was selected to move forward to flight in 2008
- After a one-year “risk reduction phase”, MAVEN transitioned to a four-year development phase for launch. MAVEN was confirmed in 2010
- MAVEN was included in the government shutdown in October 2013, less than seven weeks from launch. Launch-preparation activities were restarted after two days
- MAVEN launched on Nov. 18, 2013. This was the first day of its three-week launch period, and it launched at the first opportunity at the start of its two-hour firing window that day. MAVEN entered Mars orbit on Sept. 21, 2014
- MAVEN launched on schedule, under budget, and with the full technical capability that was intended

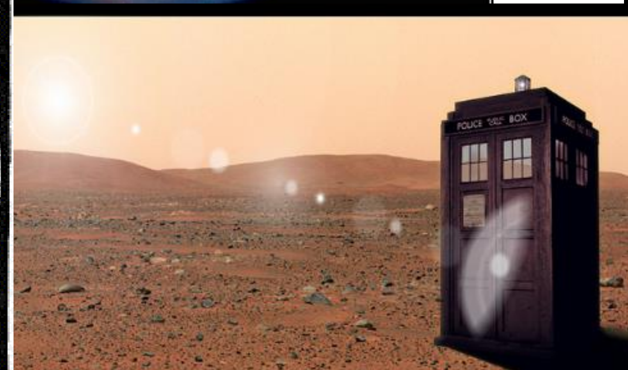
The Public's Fascination With Mars









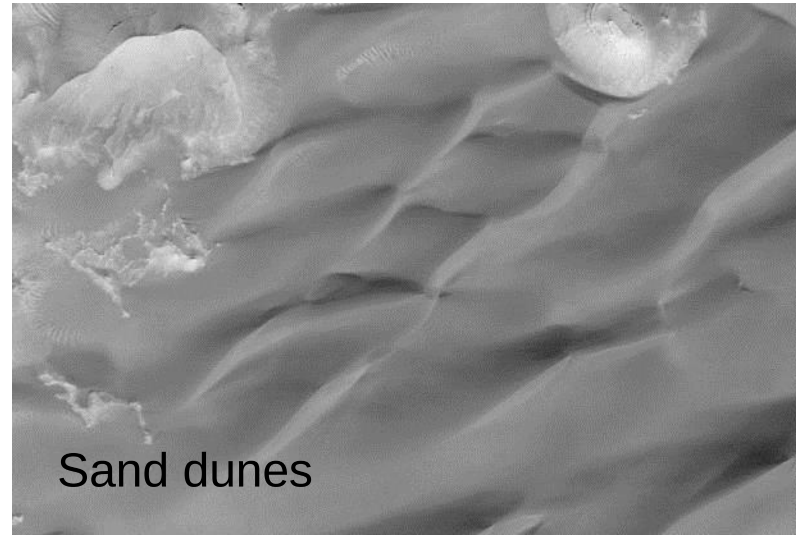


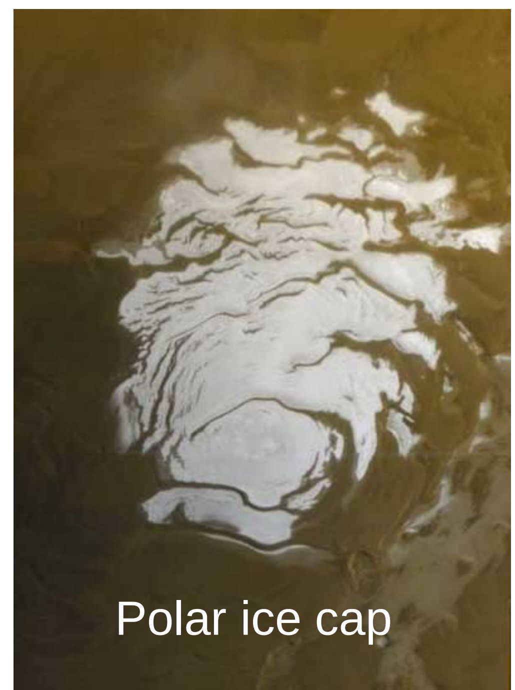
Earth

Mars

MARTIAN GEOLOGICAL FEATURES APPEAR SIMILAR TO MANY ON EARTH

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL





SCIENCE SUMMARY

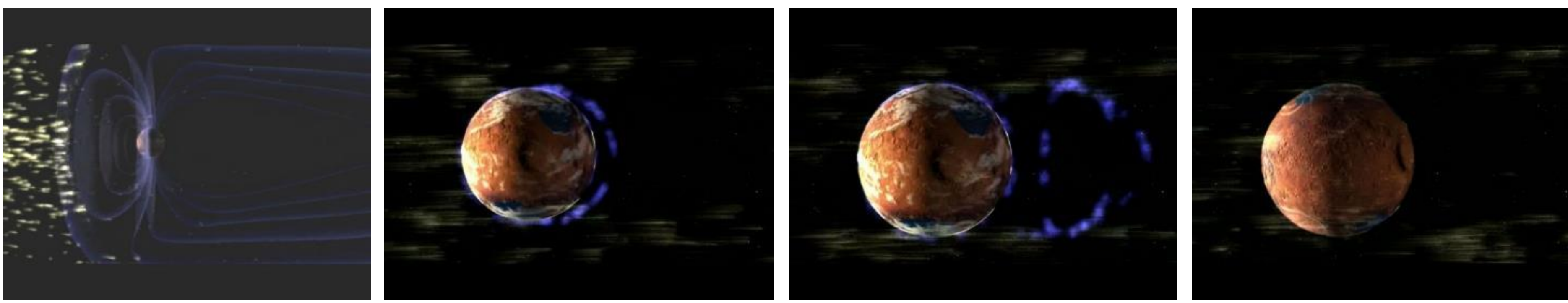
MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

Ancient Valleys

Mars' atmosphere is cold and dry today,
but there was once liquid water flowing over the surface

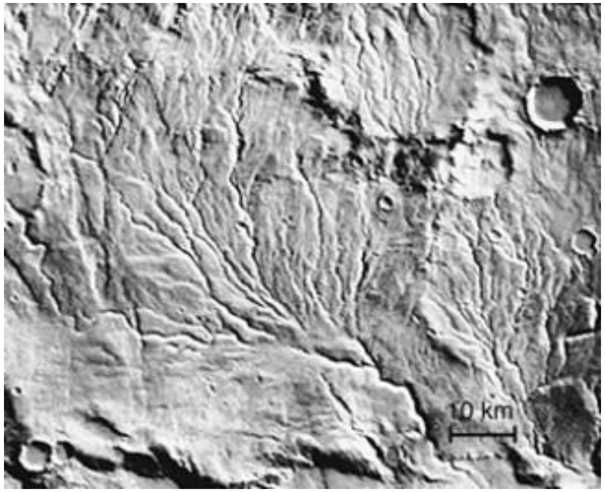
Where did the water and early atmosphere go?

- *H_2O and CO_2 can go into the crust or be lost to space*
- *MAVEN focuses on volatile loss to space*

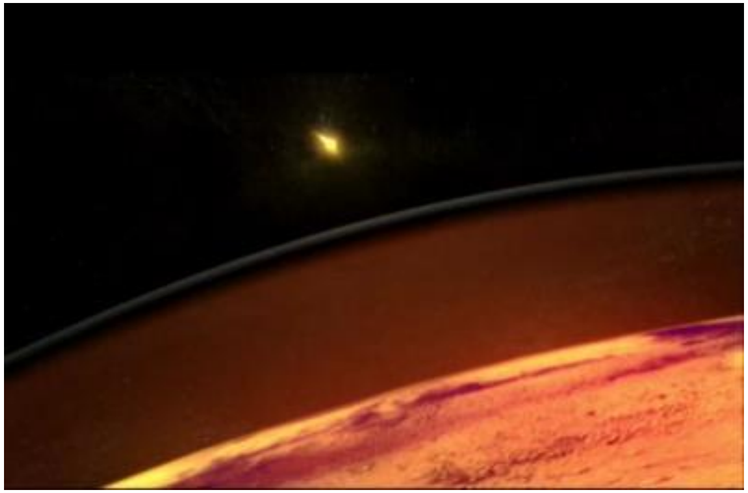


Turn-off of the Martian magnetic field allowed turn-on of solar-EUV and solar-wind stripping of the atmosphere approximately 3.7 billion years ago, resulting in the present thin, cold atmosphere

MAVEN SCIENCE OBJECTIVES



Evidence suggests that early Mars had flowing water on the surface and a thicker atmosphere.



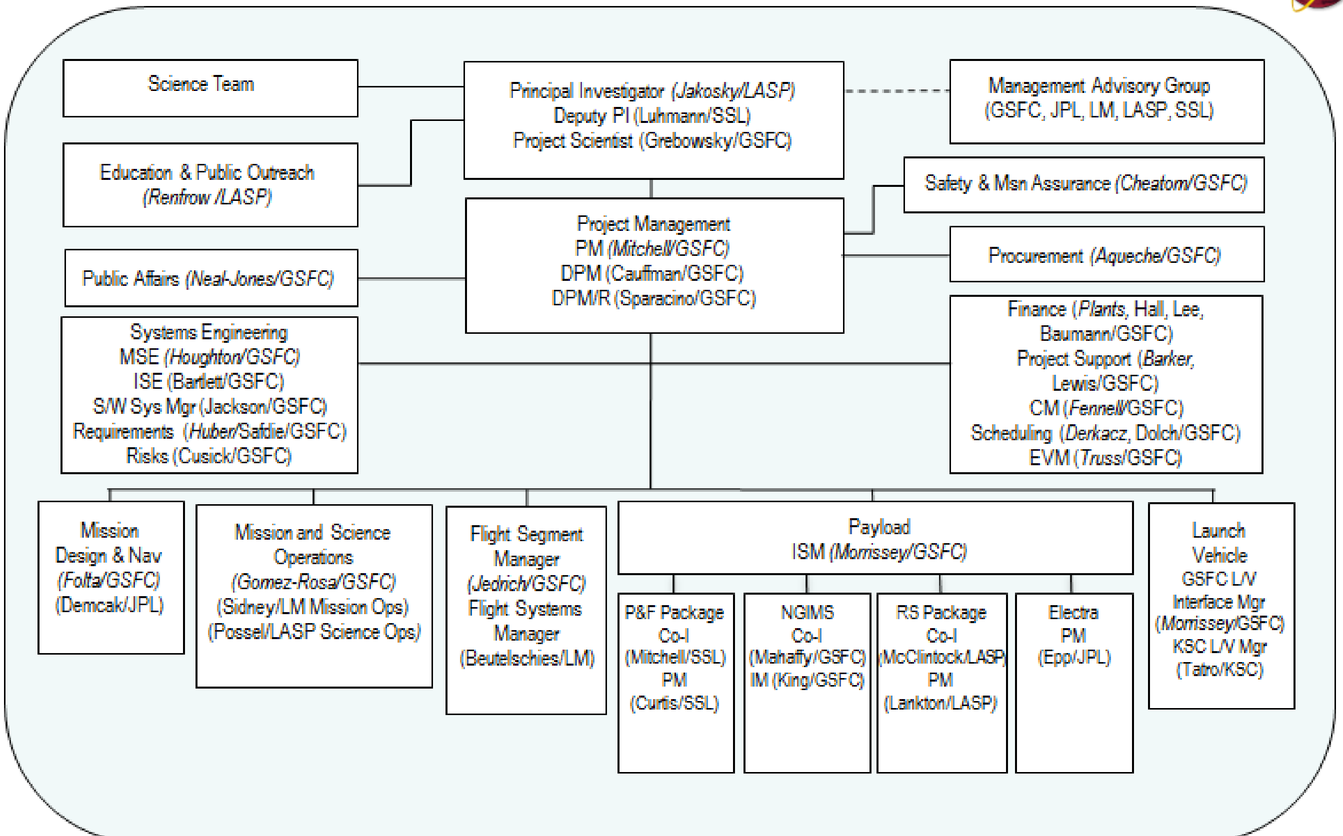
The ancient Sun was more intense and likely drove significant escape of gas to space.

- Determine the structure and composition of the Martian upper atmosphere today
- Determine rates of loss of gas to space today
- Measure properties and processes that will allow us to determine the integrated loss to space through time

MAVEN will answer questions about the history of Martian volatiles and atmosphere and help us to understand the nature of planetary habitability

AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

MAVEN PROJECT ORGANIZATION AT LAUNCH



As of 6/25/13

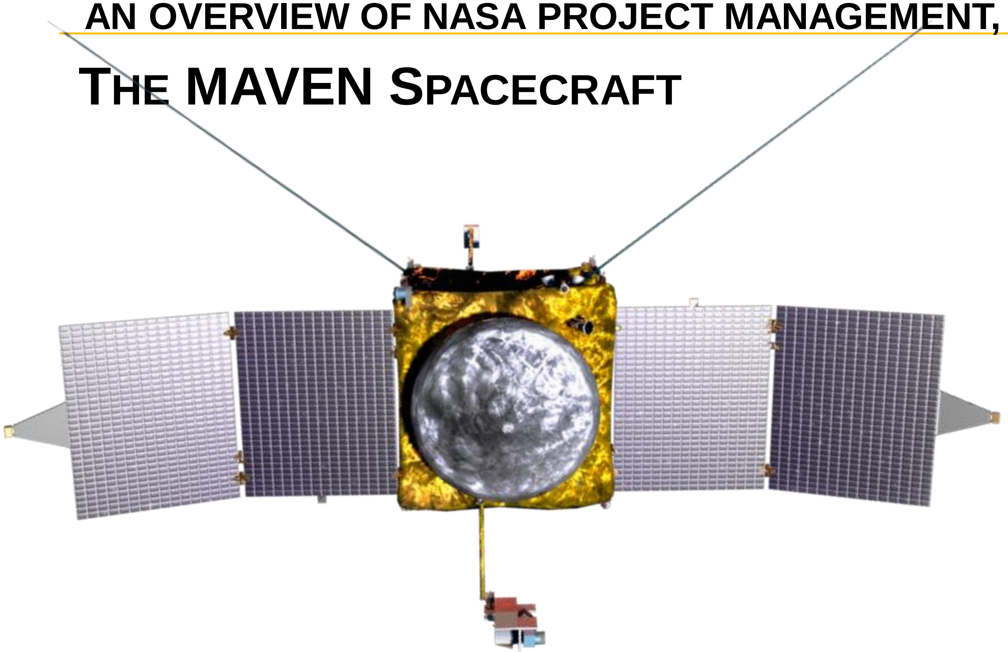
Leads are shown in Italics

- Project resides within Flight Projects Directorate, Planetary Science Projects Division
- Support from GSFC internal organizations, as well as NASA Headquarters, Jet Propulsion Laboratory, Kennedy Space Center, and industry partners is key
- Note that MAVEN is a CU-LASP PI-led mission, with project management coming from GSFC

AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

MAJOR PARTNER INSTITUTIONS

THE MAVEN SPACECRAFT



Same weight fully loaded as a GMC Yukon – 2460 kg.

Same length as a school bus – wingtip-to-wingtip length of 37.5 ft.

THE MAVEN PAYLOADS

MAVEN
Mars Atmosphere and Volatile Evolution Mission
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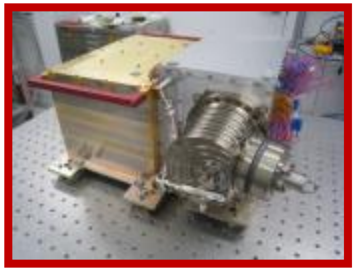
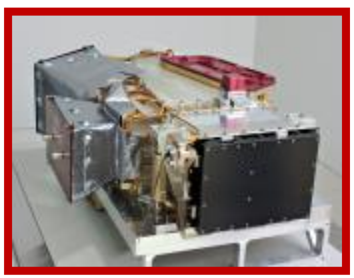
Mass Spectrometry Instrument



Neutral Gas and Ion Mass Spectrometer; Paul Mahaffy, GSFC

Remote-Sensing Package



Imaging Ultraviolet Spectrometer; Nick Schneider, LASP

Electra Relay Package

Electra UHF Transceiver and Helix Antenna; Neil Chamberlain, JPL

Particles and Fields Package


Solar Energetic Particles; Davin Larson, SSL

SupraThermal and Thermal Ion Composition; Jim McFadden, SSL


Solar Wind Electron Analyzer; David L. Mitchell, SSL

Solar Wind Ion Analyzer; Jasper Halekas, SSL


Langmuir Probe and Waves; Bob Ergun, LASP

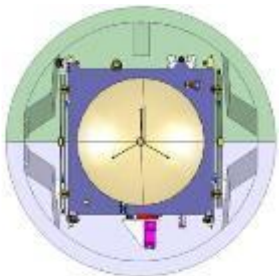
Magnetometer; Jack Connerney, GSFC

Mission Architecture

20-Day Launch Period

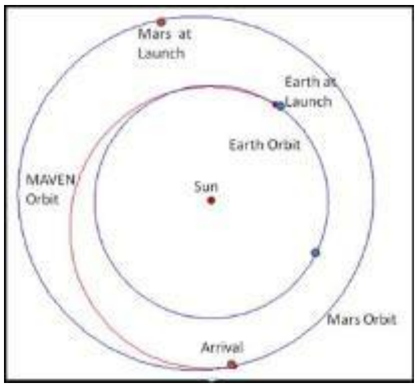
18 Nov. 2013 (launched at the open of period)

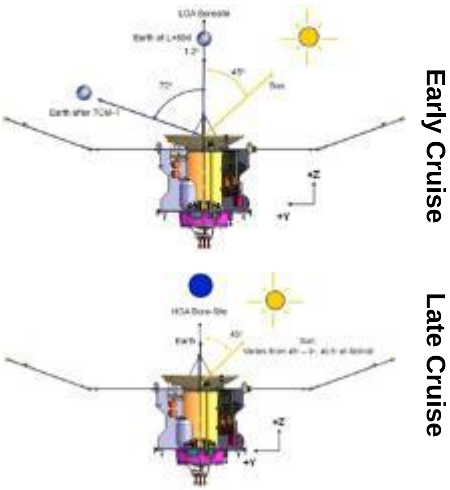
LV: Atlas V 401



10-Month Ballistic Cruise to Mars

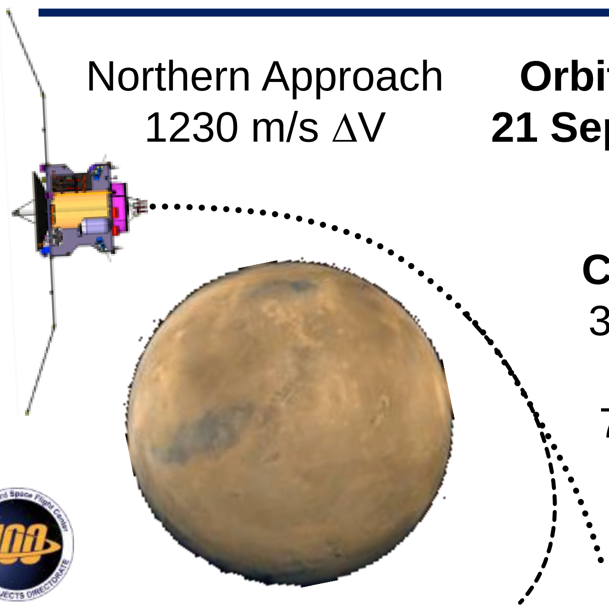
Type-II Trajectory



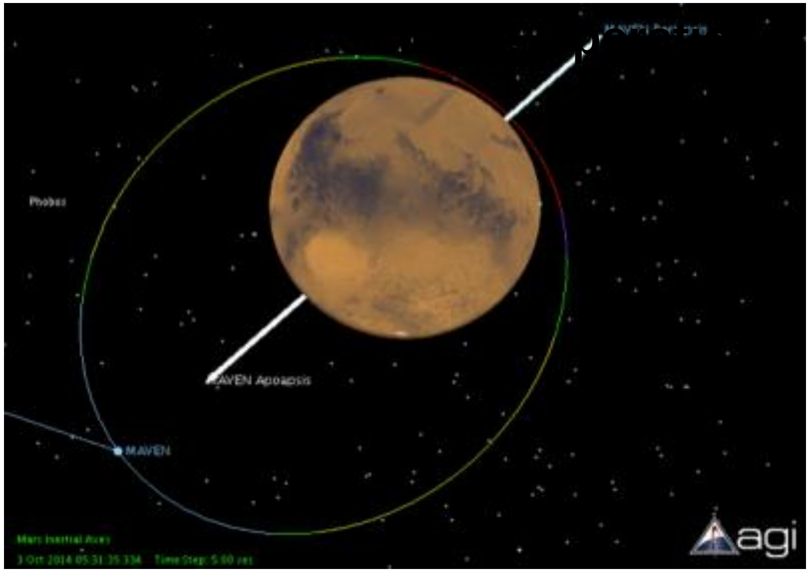


Northern Approach
1230 m/s ΔV

Orbit Insertion:
21 Sept. 2014 (ET)



Capture Orbit:
35 hour period
380 km P2
75°inclination



AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

THE MAVEN PROJECT'S JOURNEY

From Proposal Days…

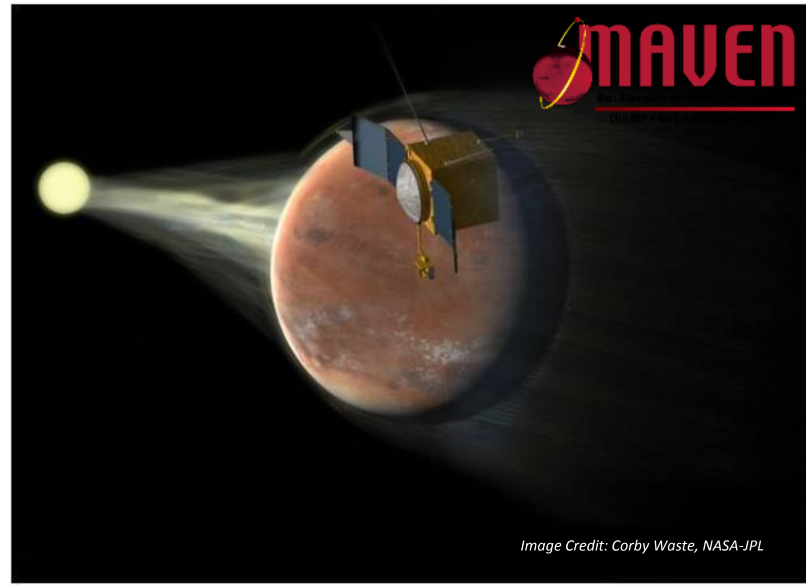
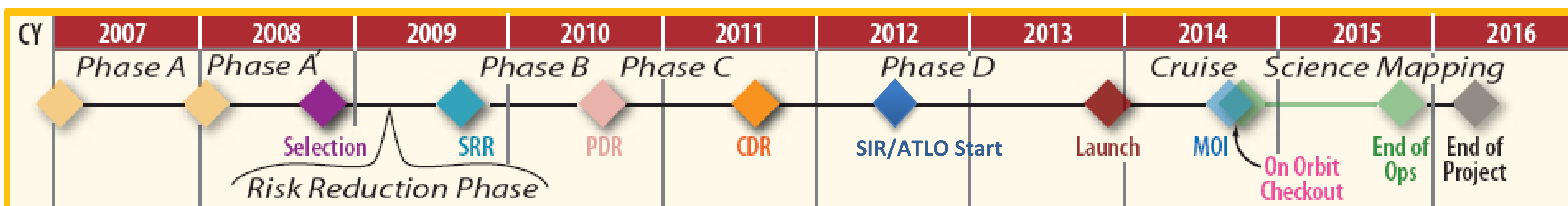


Image Credit: Corby Waste, NASA-JPL

… to Science at Mars



All major milestones, including launch, achieved on the schedule originally proposed in 2008—and under budget!

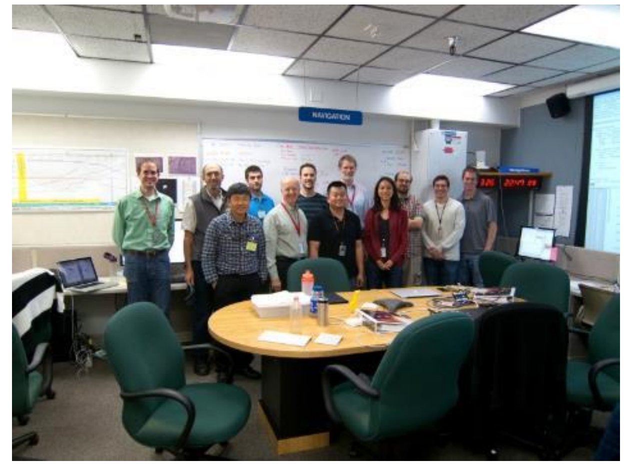
MAVEN Team During Launch Week (November 2013)

Mars Atmosphere and Volatile Evolution Mission

CU/LASP • GSFC • UCB/SSL • LM • JPL

MAVEN Team at Launch Complex-41, CCAFS

MAVEN NAV Team at JPL



MAVEN DSOC Team at JPL

MAVEN Ops Team in the MSA at LM/Denver

AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

MAVEN's Launch—November 18, 2013

MARS ORBIT INSERTION NIGHT (SEPTEMBER 21, 2014)

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

Lockheed Martin/Denver Ops Center

U. of Colorado-LASP

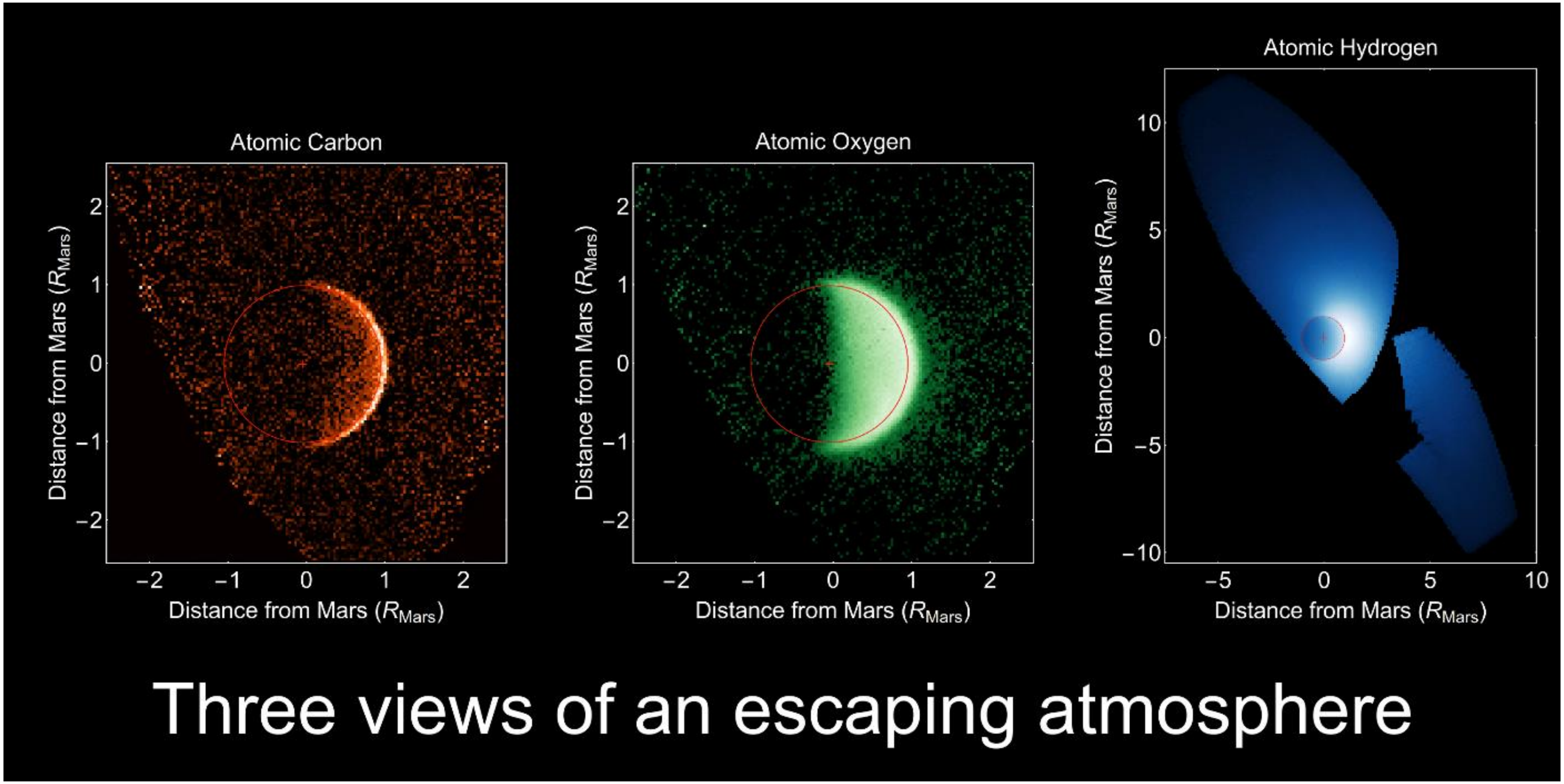
Navigation Ops at JPL

Goddard Visitors Center

U. of California-Berkeley

Backup Ops Center at NASA Goddard

PAYOFF: MAVEN OBSERVATIONS AT MARS



- Shows H, C, and O that are participating in processes leading to loss to space
- Allows us to track loss of climate-related gases H_2O and CO_2

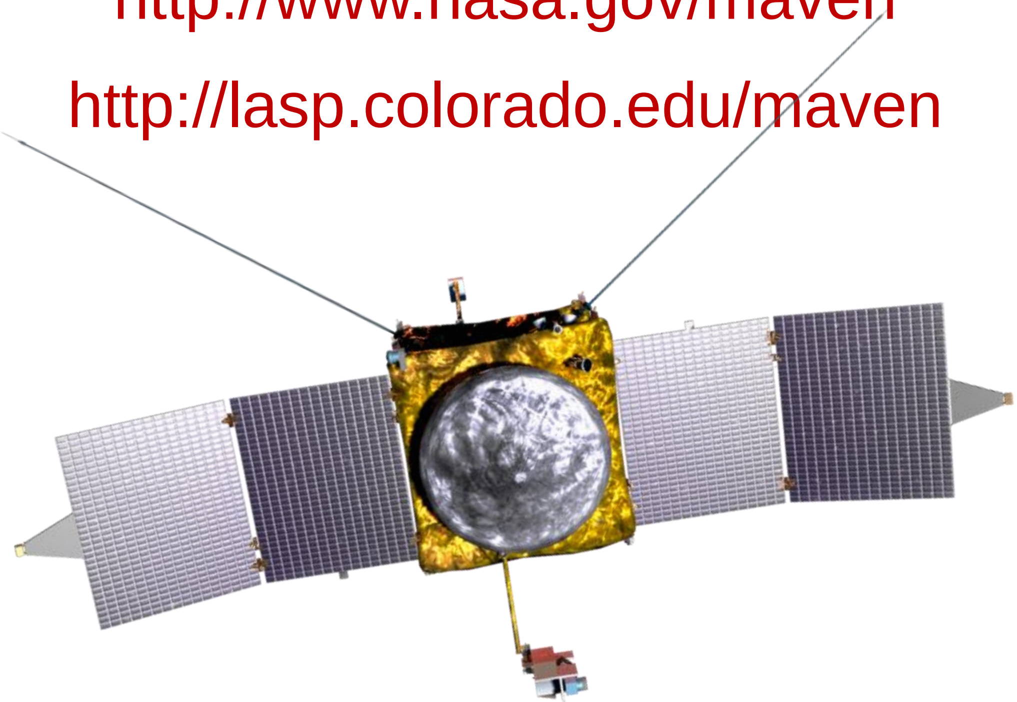
WANT TO FOLLOW MAVEN AT MARS?

We're on Facebook and Twitter: MAVEN2MARS

and on the web:

http://www.nasa.gov/maven

http://lasp.colorado.edu/maven



LESSONS LEARNED

- Failure often results from fundamental confusion over precisely what is involved in managing a project successfully from inception through completion
- Lessons learned from prior failures and successes are often neglected
  - A lessons learned analysis developed by the project team after a project is complete would be invaluable to other project managers, present and future
  - There is usually no mechanism for the lessons to get in the hands (and minds) of those who would benefit the most
  - Project teams are dispersed to other projects just at the time they should be documenting those lessons and experiences
- FPD has created a process and web site (called the Knowledge Exchange) for Flight Projects to learn from other projects, learn from within their project, and to share project lessons with other projects

"How can we remember our ignorance, which our growth requires, when we are using our knowledge all of the time"

Thoreau

Lessons Learned from the MAVEN Journey

- Stability of leadership through the project lifecycle is critical
- Push to get front line managers in the project office that have strong hardware development experience

- Maintain a sense of urgency throughout the project lifecycle even if your mission does not have a constrained planetary launch date. Time really is money
- Communicate, communicate, communicate with the project office, the PI, partner institutions, program office and NASA HQ; regular face-to-face interactions are critical. You/your team have to be road warriors
- Transparency and openness with your team is critical. You want to hear about concerns early, not days before or after launch

LESSONS LEARNED FROM THE MAVEN JOURNEY

- Fight for sufficient cost reserves at the outset of the mission – they will be needed to address many of the unknowns during development
  - Pressure to cut bid price during the competitive phase was rebuffed by the principal investigator and the project manager
  - De-scoped two instruments shortly before final proposal submission to ensure proper reserves
  - Execution is much more efficient when the project remains green throughout development rather than going yellow or red

- Resist requirements creep, both in the science and engineering areas
  - A solid mission was proposed and we stuck to it even under pressure from various corners (e.g., add a camera, add a student instrument, add a “free” foreign instrument)

LESSONS LEARNED FROM THE MAVEN JOURNEY

- Transition into Phase CDE of a project is a large effort. For a planetary project, any loss of schedule is critical. In an effort to expedite the CDE proposal process, the spacecraft contractor opened the lower level internal subsystem reviews to the project prior to submittal of the Phase CDE proposal. The result was a delivered proposal that contained no surprises

- Negotiate partner institution Phase C-E contracts before the Confirmation Review; project retired a significant cost growth risk and bounded the overall scope of effort

- The spacecraft contractor and project office personnel traveled extensively together to kickoff meetings at vendor facilities. These meetings set expectations on how we wanted the vendors to operate
- Heritage systems help but just as importantly you need the matching “heritage people” building the hardware
  - In one case, a technician who built circuit boards for previous instruments retired and the replacement tech did not implement the correct high-voltage workmanship techniques because they had not been documented

LESSONS LEARNED FROM THE MAVEN JOURNEY

- Spending money early to retire risk significantly reduced late surprises and overruns
- There was a large amount of interest from external parties that impacted "normal" work. Be prepared for significant data requests, questions, audits. Staff accordingly

- Align the earned value management systems (EVM) with WBS early in planning. Hold early face-to-face meetings with partner institutions to avoid future issues. Setting expectations took the fear out of EVM and created a collaborative environment

- Brought the joint cost/schedule confidence level (JCL) independent review team into the mix with the project 6 months before the Preliminary Design Review (PDR). This was significant in relieving any disconnects in the run up to Mission PDR and Confirmation Review

AN OVERVIEW OF NASA PROJECT MANAGEMENT, MAVEN MAGIC, AND LESSONS LEARNED

LESSONS LEARNED FROM THE MAVEN JOURNEY

MAVEN Mars Atmosphere and Volatile Evolution Mission
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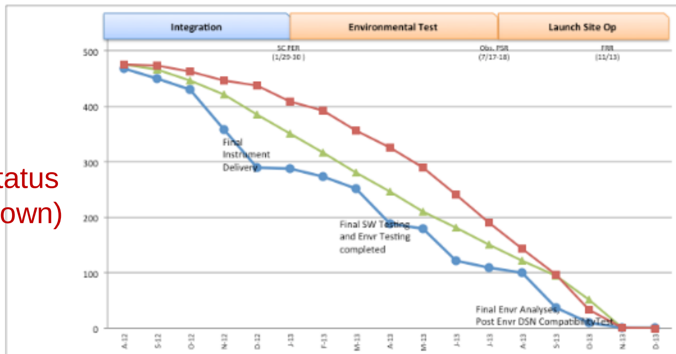
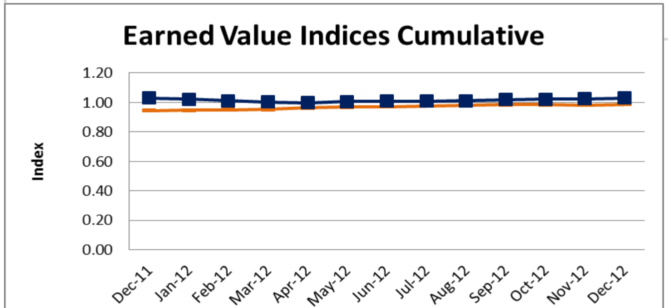
- Rigorous tracking of metrics (cost, schedule, technical) is critical to keeping leadership aware of negative trends in order to react early

Verification Status (L1 & 2 Burndown)



	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13
Verification Availability	469	450	431	359	290	287	274	252	189	180	122	110	100	37	10	1	1
Verif. Burndown Plan	475	466	446	421	386	351	316	281	246	211	181	151	121	95	51	1	0
Actuals	475	474	463	446	438	409	393	357	326	290	261	191	143	96	34	1	0

Chart presents the value at the end of the month



	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
Cum SPI	0.94	0.95	0.95	0.95	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98
Cum CPI	1.03	1.02	1.01	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.03

1/31/13

	MAVEN Critical Milestones	Need Date
1	NGIMS FM ready for Environmental Testing (GSFC)	1/7/13
2	NGIMS Vibration Test Complete (GSFC)	2/7/13
3	Delivery of SWEA Payload to LM (SSL)	3/21/13
4	Deliver NGIMS Payload to LM (GSFC)	3/25/13
5	Flight TAME Controller Available to ATLO	2/1/13
6	C&DH #1 DTCI-U Flight Spare available to ATLO (LM)	2/3/13
7	Magnetics Swing Test (ATLO)	1/10/13
8	Begin S/C Modal Survey Test (ATLO)	2/4/13
9	Re-Install TAME (ATLO)	2/5/13
10	FSW Build 5.0 Available (LM)	3/18/13
11	Begin S/C Acoustics Test (ATLO)	2/8/13
12	Begin S/C Sine Vibe Test (ATLO)	2/27/13
13	Install SWEA to Spacecraft (ATLO)	3/28/13
14	Install NGIMS to Spacecraft (ATLO)	4/1/13
15	Begin ORT 1 Test (GDS)	4/17/13
16	Begin S/C EMI/EMC Test (ATLO)	4/19/13
17	S/C Self Test #7	4/25/13
18	Begin SVT/MOI (Off-Nominal) Tests (ATLO)	5/1/13
19	Lost in Time Test (LM)	5/3/13
20	Begin Thermal Vac Test (ATLO)	5/22/13
21	Power Performance Test (ATLO)	6/11/13
22	Begin ORT 2 Launch Nominal Test (GDS)	6/12/13
23	Payload Final Performance Test (ATLO)	6/21/13
24	Dry Spin Balance Test Complete (ATLO)	7/9/13

1 - Reviewing TAME PWB coupons to determine useability
2 - SWEA is diagnosing issues with high voltage discharges.SWEA was decoupled from the PFP package and to be shipped separately.
3 - DTCI Fabrication delayed
4 - EMI/EMC Test moved to accommodate NGIMS delivery
5 - FSW 5.0 delayed to accommodate additional changes

Review	Review Held / Scheduled	Actions	Submitted	% Submitted	Closed	% Closed
RSS PER	4/10/12	5	5	100%	5	100%
PFP PER	5/22/12	7	7	100%	7	100%
NGIMS PER	10/15/12	2	2	100%	2	100%
Spacecraft PER	1/29/13	5	3	60%	3	60%
SIR	6/25/12	4	4	100%	4	100%
Electra HRCR (JPL Internal)	6/21/12	0	n/a	n/a	n/a	n/a
RSS PSR	10/24/12	1	1	100%	1	100%
PFP PSR	10/30/12	1	1	100%	1	100%
NGIMS PSR	TBD	TBD	-	-	-	-
Observatory PSR	7/16/13	TBD	-	-	-	-
MOS/GDS Peer Review	6/5/12	0	n/a	n/a	n/a	n/a
MOR	11/13/12	14	8	57%	6	43%
ORR/FOR	8/13/13	TBD	-	-	-	-
Totals		**39**	**31**	**79%**	**29**	**74%**

Lessons Learned from the MAVEN Journey

- The first lesson in planning is that you can't plan for everything. We encountered plenty of issues on our mission that required us to assess the impacts and move forward with Plan B. Surprises along the way:
  - Two instruments were delivered months late, during the year of launch
  - Application of a new material (MetGlas) in a heritage system and impacts in I&T. Must fully evaluate new materials and their application prior to use
  - Sequestration, with imposition of a travel cap in FY 2012 that threatened the mission's approach to conducting business
  - FY 2014 furlough beginning 7 weeks before scheduled launch and how we preserved the mission's full launch period
  - Removal of an instrument at the launch site for rework back at Goddard (the "Cannot Duplicate Problem" that surfaced again during launch preparations at Kennedy Space Center, and forced a late, tough decision)
  - Comet Siding Spring – truly an "unknown" when we bid the mission in 2008. This comet was discovered in January 2013 and drove a significant amount of analysis and mitigation planning and implementation for the October 2014 encounter
- Find opportunities to team build at frequent intervals and schedule in lessons learned opportunities during every phase of development

The Flight Projects Directorate manages a myriad of in-house and out-of-house flight projects that concentrate on earth and space science, and exploration.

An integrated approach to science, engineering, safety and mission assurance, and management enables us to take on and accomplish the most challenging of missions, of which MAVEN was one.

These make for exciting times for NASA, Goddard, and all of our partners.


It is difficult to say what is impossible…
for the dream of YESTERDAY
is the hope of TODAY
and the reality of
TOMORROW.
- Robert H. Goddard (1882 - 1945)